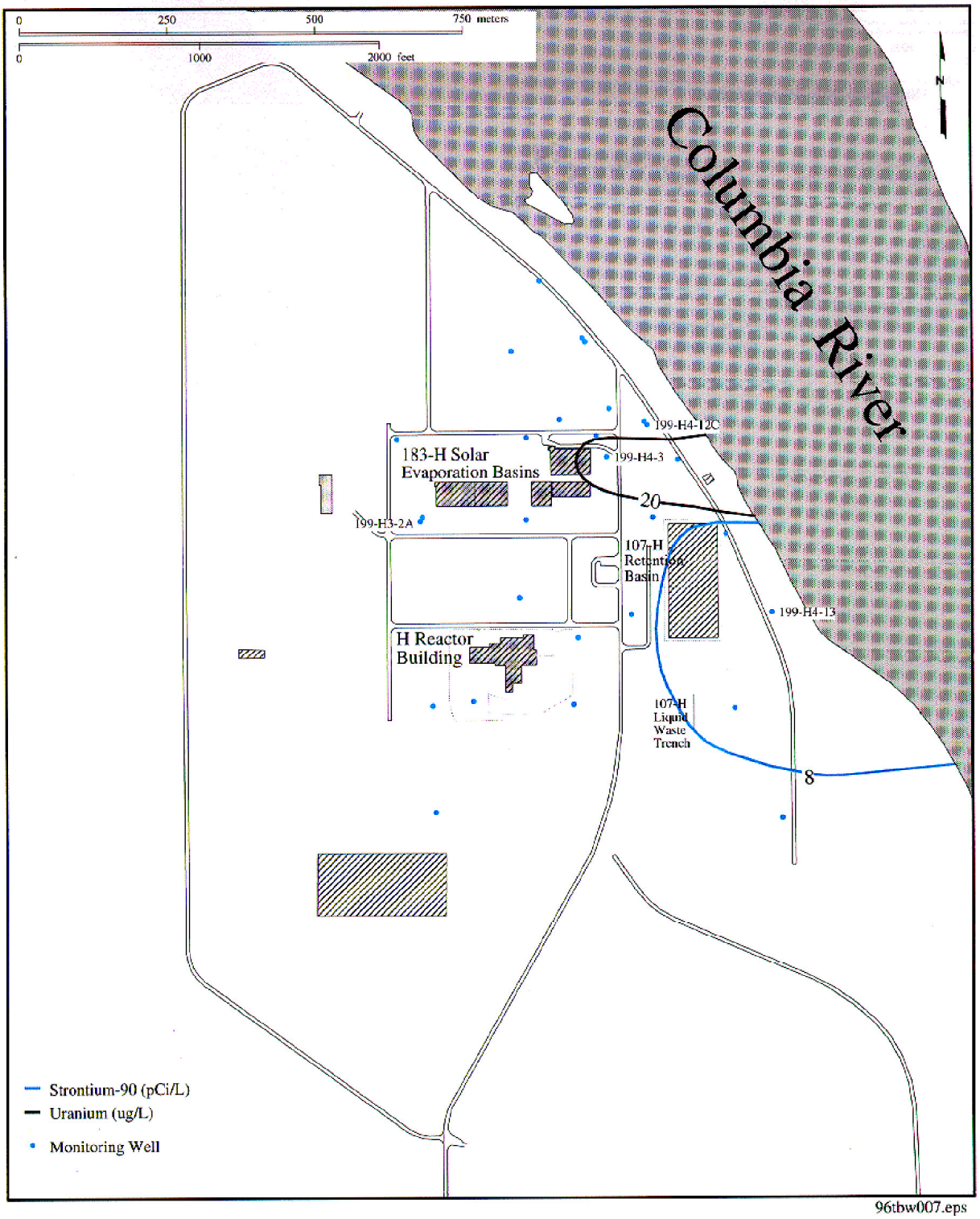

Figure 4.8.25. Concentrations of Strontium-90 and Uranium in the Unconfined Aquifer in the 100-H Area, 1995

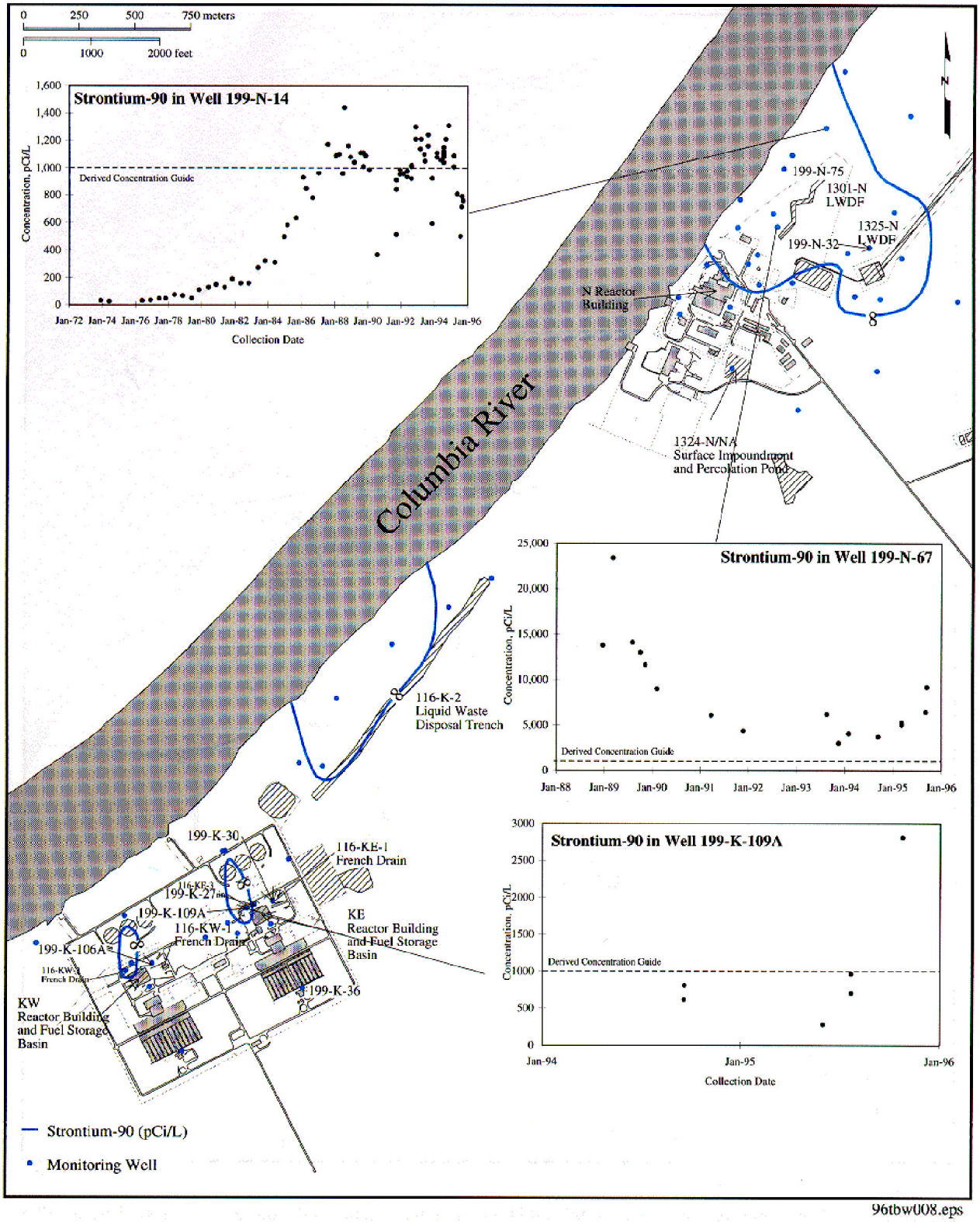

Figure 4.8.26. Concentrations of Strontium-90 in the Unconfined Aquifer in the 100-K and 100-N Areas, 1995, and Concentration Trends in Selected Wells

environmental monitoring programs (see Section 4.2, "Surface Water and Sediment Surveillance"). The movement of the strontium-90 plume northward in the 1980s is illustrated by the trend data from well 199-N-14 (Figure 4.8.26). The strontium-90 concentrations in this well have remained approximately level, or have declined slightly since 1989. Wells farther northeast do not show detectable strontium-90. The steady levels indicate the plume is not spreading north at this time. Remediation of strontium-90 in the 100-N Area by pump-and-treat method began in 1995.

Strontium-90 in the 200 Areas. Concentrations of strontium-90 in the 200-East Area ranged up to 4,710 pCi/L in well 299-E28-23 near the 216-B-5 Reverse Injection Well. Strontium-90 was also found at 71.9 pCi/L in well 299-E28-2, which is approximately 150 m (490 ft) from the 216-B-5 injection well. Strontium-90 distribution in the 200-East Area is shown in Figure 4.8.27. Strontium-90 was detected in 1995 at levels above the Drinking Water Standard in two wells, 299-E17-14 and 299-E17-8, near the Plutonium-Uranium Extraction Plant cribs. The maximum concentration of strontium-90 detected in 1995 in this vicinity was 14.9 pCi/L in well 299-E17-14.

Strontium-90 is detected occasionally in the 200-West Area. In 1995, samples from two wells exceeded the Drinking Water Standard, with the maximum concentration detected at 71.3 pCi/L in well 299-W22-1, located in the southern part of the 200-West Area.

Strontium-90 in the 600 Area. Concentrations of strontium-90 greater than the Drinking Water Standard but less than the DOE Derived Concentration Guide of 1,000 pCi/L were detected in several wells in the former Gable Mountain Pond area (Figure 4.8.27). Strontium-90 contamination in this area resulted from the discharge of radioactive waste to the former Gable Mountain Pond during its early use. Strontium-90 has since migrated through the sedimentary column to the ground water, which is relatively close to the surface at that location. Initial breakthrough occurred in 1980 in some areas. The depth to bedrock is also small in the former Gable Mountain Pond area, and strontium-90 has been detected in wells completed in the basalt just below the unconsolidated sediments. The maximum concentration of strontium-90 detected in the former Gable Mountain Pond area was 730 pCi/L in well 699-53-47B.

Technetium-99

Technetium-99 is produced as a fission by-product and is present in waste streams associated with fuel processing. Reactor operations may also result in the release of some technetium-99 associated with fuel element breaches. Technetium-99 is normally present in solution as anions that sorb poorly to sediments so technetium is very mobile in Hanford Site ground water.

Technetium-99 was found at concentrations greater than the 900-pCi/L Drinking Water Standard in several areas of the Hanford Site. One location is downgradient of the 183-H solar evaporation basins in the 100-H Area. These basins were used for storage of waste primarily from fuel fabrication in the 300 Area. Some of the waste leaked into the subsurface, contaminating the ground water. The maximum concentration of technetium-99 detected in this area in 1995 was in well 199-H4-3, where the highest sample contained 4,980 pCi/L. This is the only well where technetium-99 was detected above the Drinking Water Standard; thus, this plume appears to be very narrow and restricted to a small area between the basins and the Columbia River.

Ground water from the northwestern part of the 200-East Area, and a part of the 600 Area extending north toward the gap between Gable Mountain and Gable Butte, contains technetium-99 at concentrations above the Drinking Water Standard (Figure 4.8.27). The source of this technetium was apparently the BY Cribs (Dresel et al. 1995). The technetium-99 plume is associated with cobalt-60, cyanide, and tritium contamination. The maximum technetium-99 concentration detected in this plume in 1995 was 9,910 pCi/L in well 699-50-53A. This well had been used as an extraction well for testing pump-and-treat technology for ground-water remediation. The technetium-99 trend for well 699-52-54 shows the progress of this plume as it migrates north (Figure 4.8.28). The concentration in well 699-52-54 in 1995 was similar to the concentration in 1994.

Technetium-99 is also detected at levels greater than the Drinking Water Standard in the 200-West Area and the adjacent 600 Area (Figure 4.8.29). The largest technetium-99 plume in the 200-West Area originates in the cribs that received effluent from U Plant. The maximum technetium-99 concentration detected in the 200-West Area in 1995 was in well 299-W19-30, which

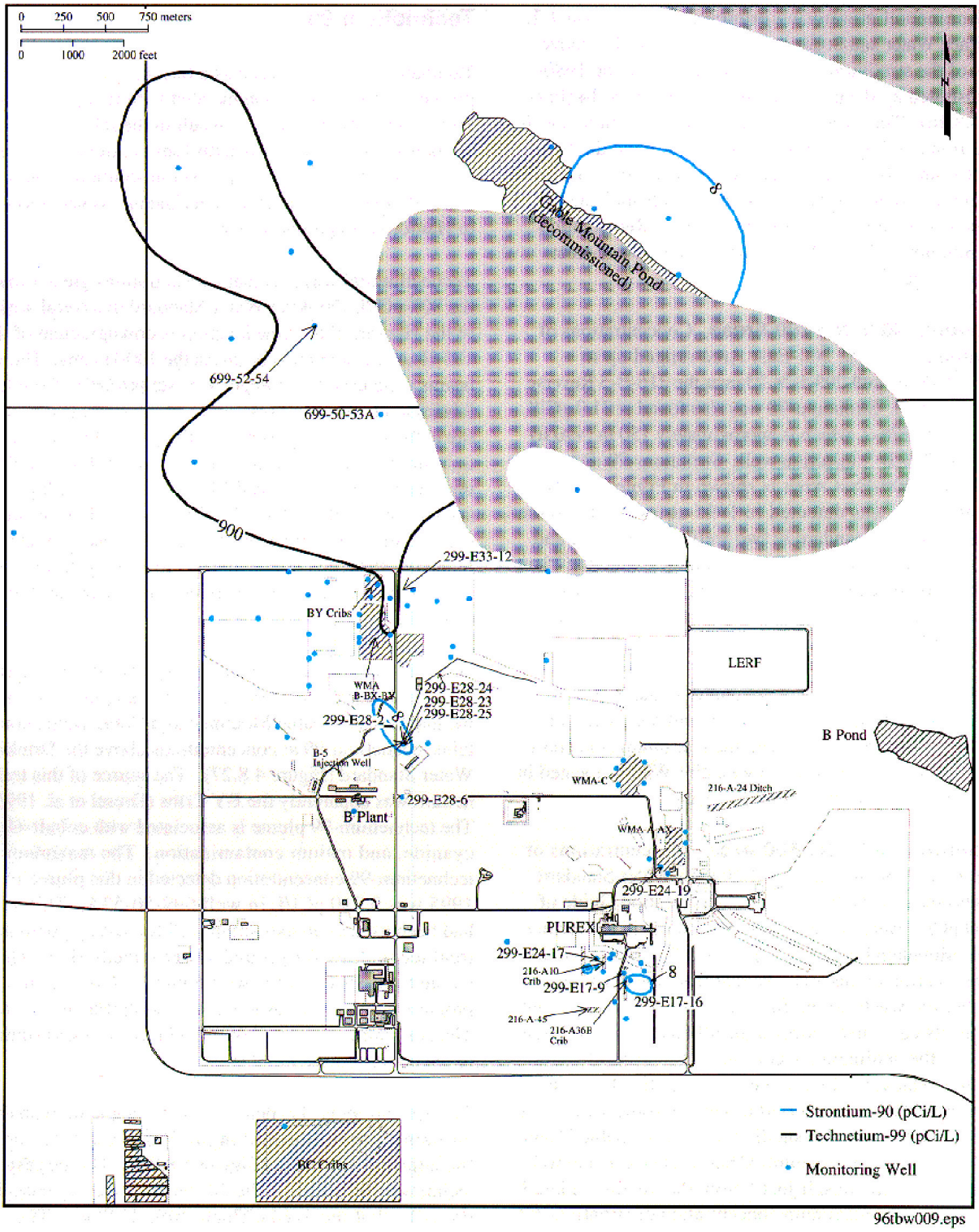

Figure 4.8.27. Concentrations of Strontium-90 and Technetium-99 in the Unconfined Aquifer Near the 200-East Area, 1995

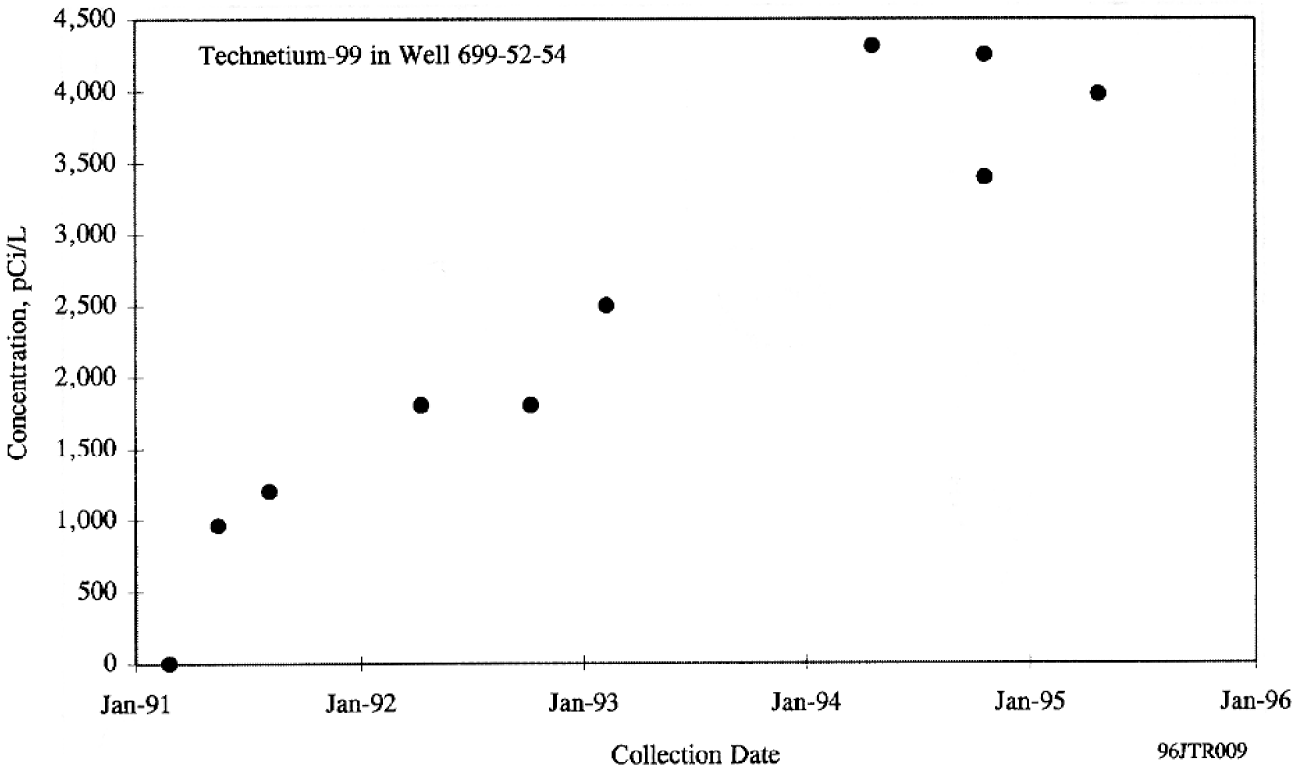

Figure 4.8.28. Technetium-99 Concentrations in Well 699-52-54, 1991 Through 1995

had a technetium-99 concentration of 12,700 pCi/L. This plume extends well into the 600 Area towards the 200-East Area. The highest concentration part of this plume is currently undergoing remediation by the pump-and-treat method.

Several smaller areas with technetium-99 greater than the Drinking Water Standard were also found in the 200-West Area. The northernmost technetium-99 plume in the 200-West Area is essentially coincident with the northern tritium plume and appears to originate in the vicinity of the WMA-TY-TX single-shell, high-level waste tanks and nearby disposal facilities. Only one well in this plume contained technetium-99 at levels above the Drinking Water Standard.

The southernmost plume in the 200-West Area originates near the WMA-S-SX high-level waste, single-shell tank farm and nearby disposal facilities. In 1994, samples from two wells in this area were above the Drinking Water Standard for technetium-99 (Dirkes and Hanf 1995) but in 1995, all samples were below the Drinking Water Standard. The source of the technetium-99 in this vicinity has not been identified. Although many of the high-level waste tanks are assumed to have leaked, similar wastes but at lower concentrations were discharged to nearby cribs. In addition, transfer pipelines in the tank farm had leaked during tank farm operations and are potentially an additional source of contamination.

Uranium

There are numerous possible sources of uranium released to the ground water at the Hanford Site including fuel fabrication, fuel processing, and uranium recovery operations. Uranium may exist in several states including elemental uranium or uranium oxide as well as tetravalent and hexavalent cations. Only the hexavalent form has significant mobility in ground water, largely by forming dissolved carbonate species. Uranium mobility is thus dependent on both oxidation state and pH. Uranium is observed to migrate in Hanford ground water but is retarded relative to more mobile species such as technetium-99 and tritium.

The EPA has proposed a Drinking Water Standard of 20 µg/L for uranium. This is in contrast to other radionuclides for which the standards are given in picocuries per liter. The reason for the different units relates to evidence that uranium ingestion may cause kidney damage,

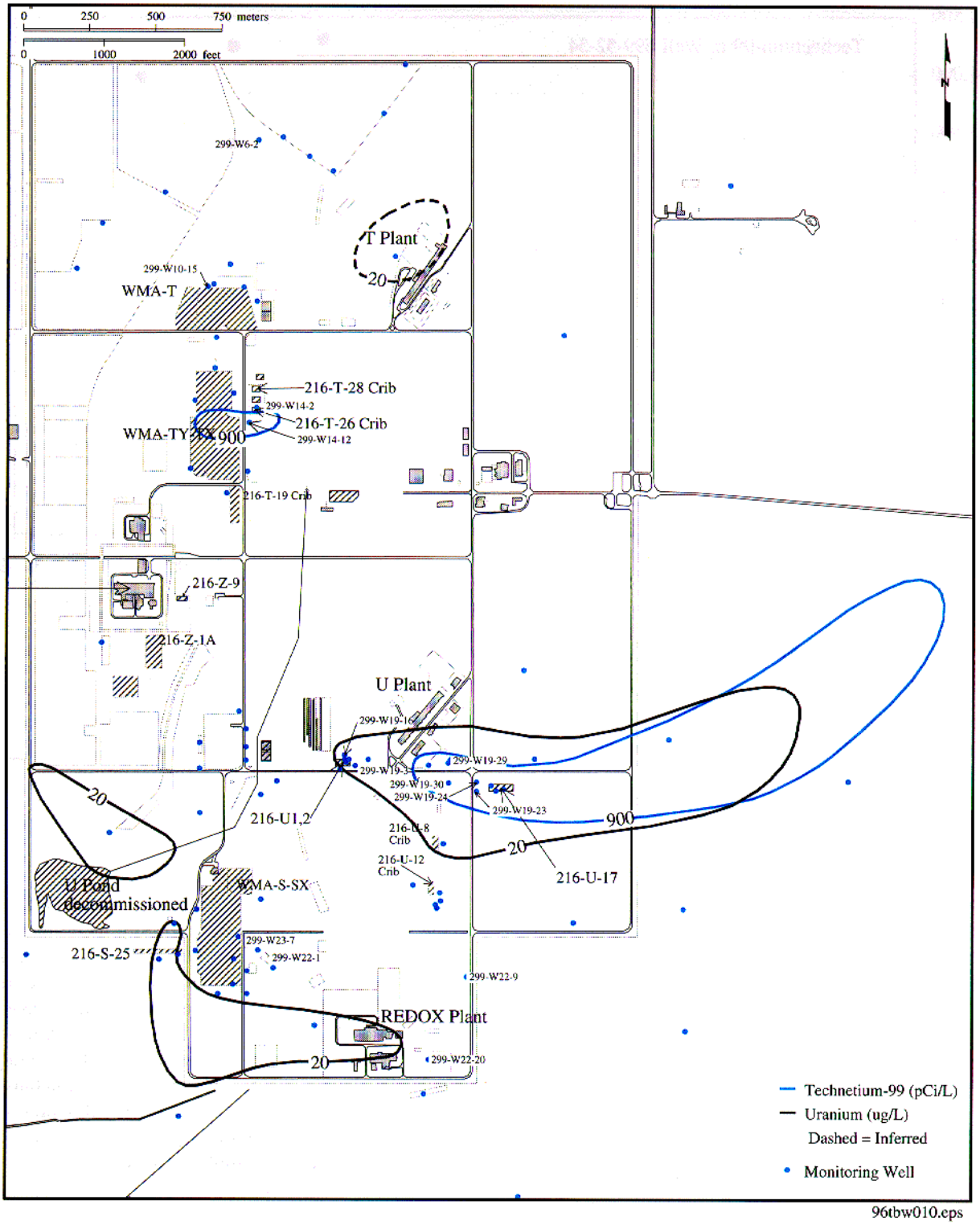

Figure 4.8.29. Concentrations of Technetium-99 and Uranium in the Unconfined Aquifer in the 200-West Area, 1995

which is assessed as a chemical hazard rather than a radiological hazard. However, uranium may be analyzed by an alpha-counting method and has an associated risk through its radioactivity, so it is important to be able to convert between ground-water concentrations expressed in micrograms per liter and those expressed in picocuries per liter. The conversion factor depends on the proportions of uranium-234, -235, and -238 in the ground water. The EPA considers the proposed Drinking Water Standard of 20 µg/L to be equivalent to a standard of 30 pCi/L, based on a series of ground-water analyses throughout the United States (40 CFR 141 and 142). However, site-specific data for Hanford indicate that the proportion of the different uranium isotopes in ground water is similar to the average proportion in natural rock. In this case, the uranium activity in picocuries per liter should be multiplied by 1.49 to convert to the concentration in micrograms per liter. This means that the proposed Drinking Water Standard is equivalent to 13.4 pCi/L.

Uranium has been detected at concentrations greater than the proposed Drinking Water Standard in the 100-F, 100-H, 200-East, 200-West, 300, and 600 Areas. The highest concentrations detected onsite in 1995 were in the 200-West Area, near the U Plant.

Uranium in the 100 Areas. In 1995, uranium was detected at concentrations greater than the proposed Drinking Water Standard near the reactor building in the 100-F Area (Figure 4.8.24). The maximum concentration detected was 257 µg/L in well 199-F8-1.

Uranium was detected at concentrations greater than the proposed Drinking Water Standard in two wells in the 100-H Area (Figure 4.8.25). The maximum concentration detected in 1995 was 273 µg/L in well 199-H4-3. Uranium concentrations in this well fluctuate widely; the lowest concentration detected in this well in 1995 was 64.7 µg/L.

Uranium in the 200 Areas. A few wells in the 200-East Area contained uranium at concentrations greater than the proposed Drinking Water Standard for at least one sampling event. The highest concentration detected in the 200-East Area was 50.8 µg/L in well 299-E28-6, located to the east of B Plant in the central part of the area.

The highest uranium levels in Hanford ground water occurred near U Plant in the 200-West Area in wells adjacent to the inactive 216-U-1, 216-U-2, and 216-U-17 cribs (Figure 4.8.29). Uranium concentrations in these wells have been decreasing over the last 5 years following remediation activities associated with those cribs. A trend plot of uranium concentrations in samples from well 299-W19-3, immediately downgradient from the 216-U-1 and 216-U-2 cribs, is shown in Figure 4.8.30. The uranium levels in this well continue to decrease slowly but remain greater than the proposed Drinking Water Standard. The maximum concentration detected in this area was 16,400 µg/L in a sample from well 299-W19-24. This value is considerably higher than values detected in previous years. Samples from two other nearby wells were analyzed in the same batch and were also anomalously high. These values may represent gross errors in the analysis. These wells are located in the area being remediated by pump-and-treat methods. Except for the above samples, the maximum uranium detected in this area in 1995 was 2,540 µg/L in well 299-W19-29. Results from that well have been erratic since 1991. However, the maximum concentration detected in well 299-W19-29 represents isotopic values greater than the DOE Derived Concentration Guides of 500 pCi/L for uranium-234 and 600 pCi/L for uranium-238. This uranium plume extends east into the 600 Area along with the technetium-99 discussed above. The uranium, at levels above the proposed Drinking Water Standard, does not extend as far east as the technetium-99 in this plume. Other areas within the 200-West Area with uranium contamination are also shown in Figure 4.8.29, including fairly widespread areas west and northwest of the Reduction-Oxidation Plant. Uranium concentrations in those areas are considerably lower than the concentrations detected near U Plant.

Uranium in the 300 Areas. A plume of uranium exists in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive waste sites known to have received uranium waste. The plume extends downgradient from inactive Liquid Waste Disposal Facilities to the Columbia River (Figure 4.8.31). In recent years, uranium concentrations have fallen in the northern part of the plume, risen in the central part, and remained fairly constant in the southern part, as shown in the trend plots in Figure 4.8.31. The maximum concentration of uranium detected in the 300 Area in 1995 was 247 µg/L in well 399-1-17A, located adjacent to the 300 Area Process Trenches. An Expedited Response Action performed on the 300 Area Process Trenches in mid-1991 was aimed at reducing the uranium source in that area. Use of the trenches for disposal of cooling water and small quantities of nonhazardous maintenance and process waste (Borghese 1994) was resumed following completion of the remedial action, although discharge to the trenches was much lower than before the expedited

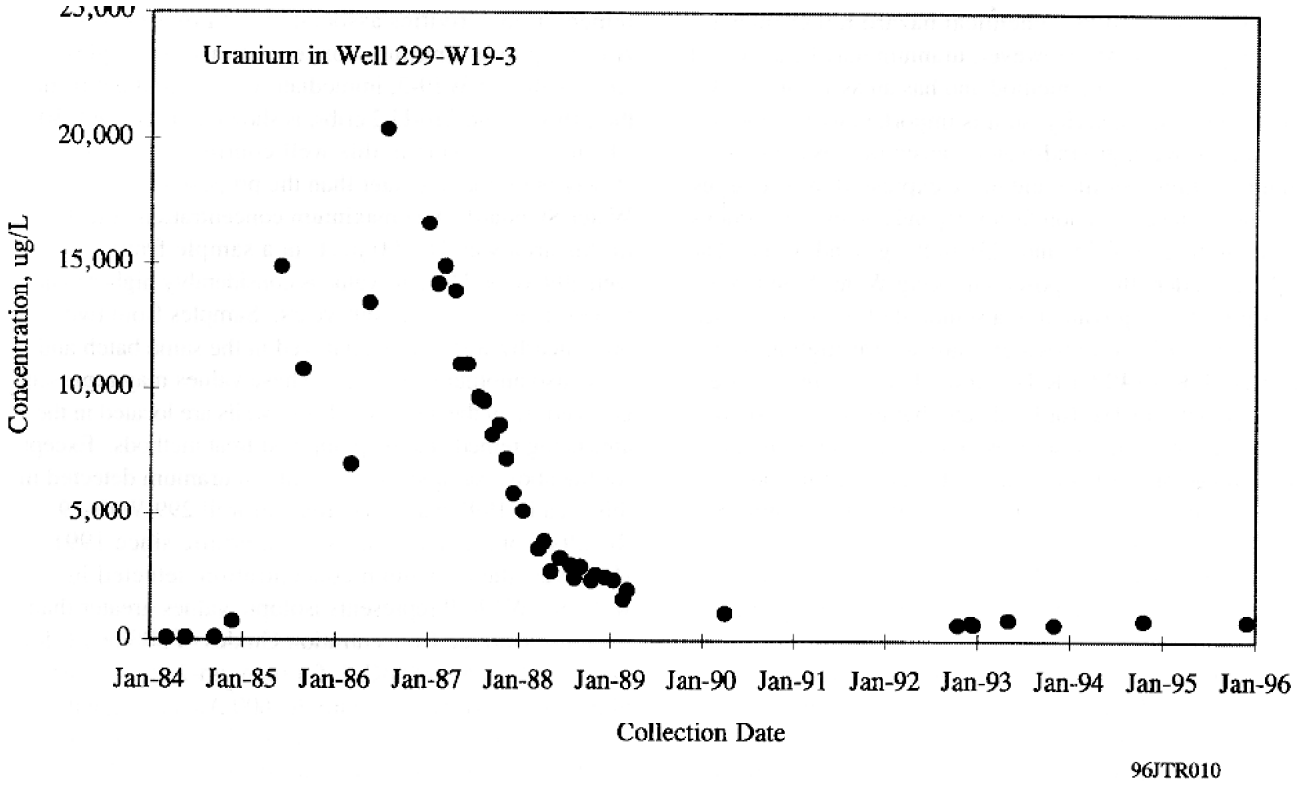

Figure 4.8.30. Uranium Concentrations in Well 299-W19-3, 1984 Through 1995

response and ceased completely in 1995. Uranium levels in well 399-1-17A, located near the trenches, were lower following that remedial action. However, levels increased sharply in late 1994 and 1995. This increase is probably related to the cessation of discharge of water to the trenches. Recent discharges have been low in uranium because fuel fabrication activities have ceased. The sudden increase after discharges were terminated is most likely related to redistribution of contamination in the aquifer or reequilibration of the water with the sediments. A trend plot showing the uranium concentrations in well 399-1-17A is shown in Figure 4.8.32.

High levels of uranium (768 µg/L) were detected in 1995 in well 699-S6-E4A, which is located near the 618-10 burial grounds. This well was not designed as a monitoring well but was sampled as part of Comprehensive Environmental Response, Compensation, and Liability Act investigations. The well will be renovated and resampled in 1996. The well is open to the unconfined aquifer at depths well below the water table. The uranium level measured in well 699-S6-E4A equates to a potential drinking water dose of 97 mrem/yr, which is just below the DOE 100 mrem standard, assuming natural isotopic abundance.

Cobalt-60

Cobalt-60 is a neutron activation product typically associated with wastes generated by processing reactor effluent water. Cobalt-60 is normally present as a divalent transition metal cation and as such tends to be highly immobile in ground water but may be mobilized by complexing agents.

Low levels of cobalt-60 were detected in 100-N Area wells. The maximum concentration detected was 15.1 pCi/L in well 199-N-32.

Cobalt-60 was detected at levels above the Drinking Water Standard of 100 pCi/L in the 600 Area north of the 200-East Area. The maximum concentration of cobalt-60 detected was 166 pCi/L in well 699-50-53A. The cobalt-60 plume is found in the same area as the technetium-99 contamination associated with the BY cribs. Several 200-East Area wells near the BY Cribs had low levels of cobalt-60, with the highest reported value of 31 pCi/L from well 299-E33-12, which is completed in the upper basalt confined aquifer system. The cobalt in the plume from the BY Cribs is apparently mobilized by reaction with cyanide or ferrocyanide, forming a dissolved cobalt species.

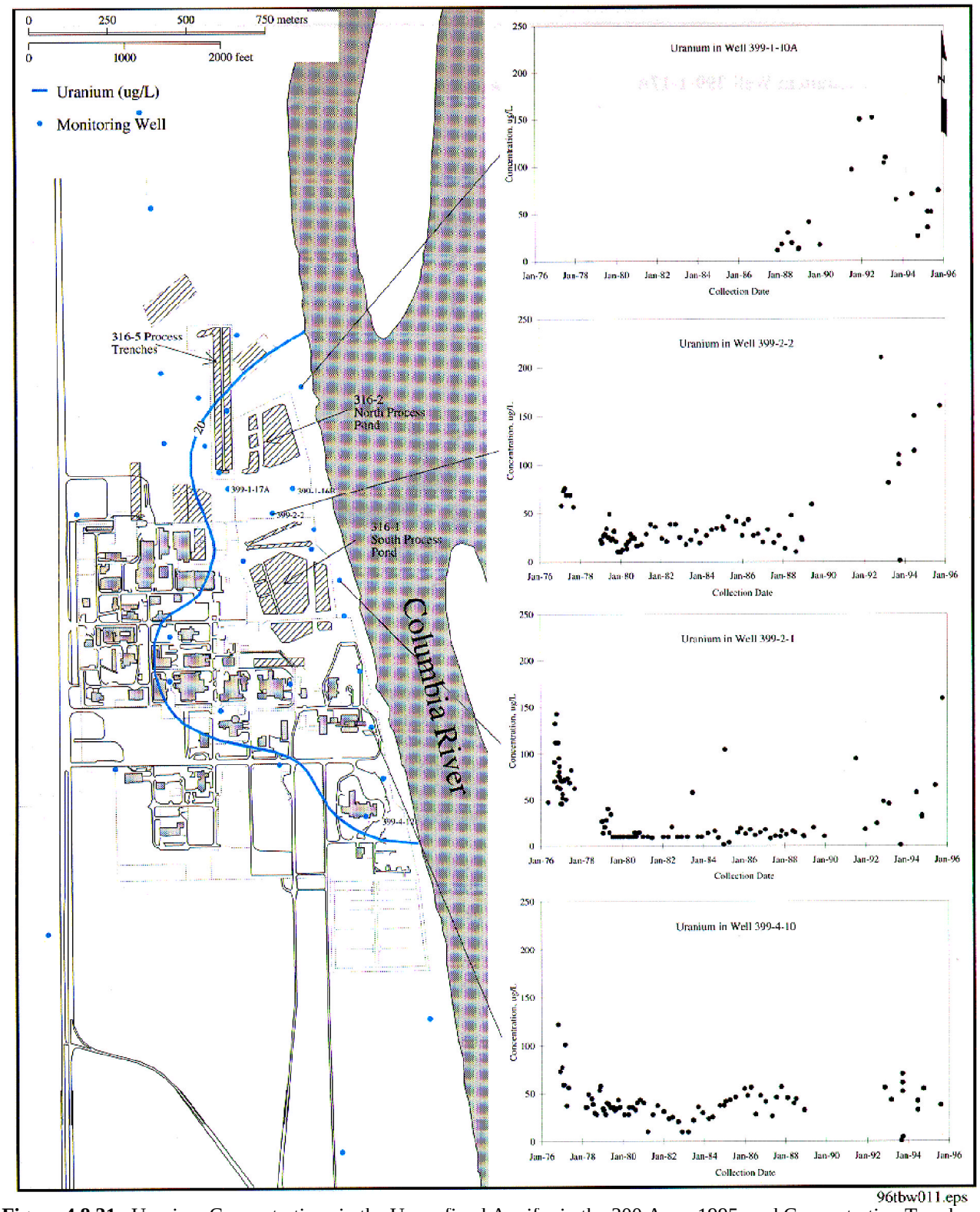

Figure 4.8.31. Uranium Concentrations in the Unconfined Aquifer in the 300 Area, 1995, and Concentration Trends for Selected Wells

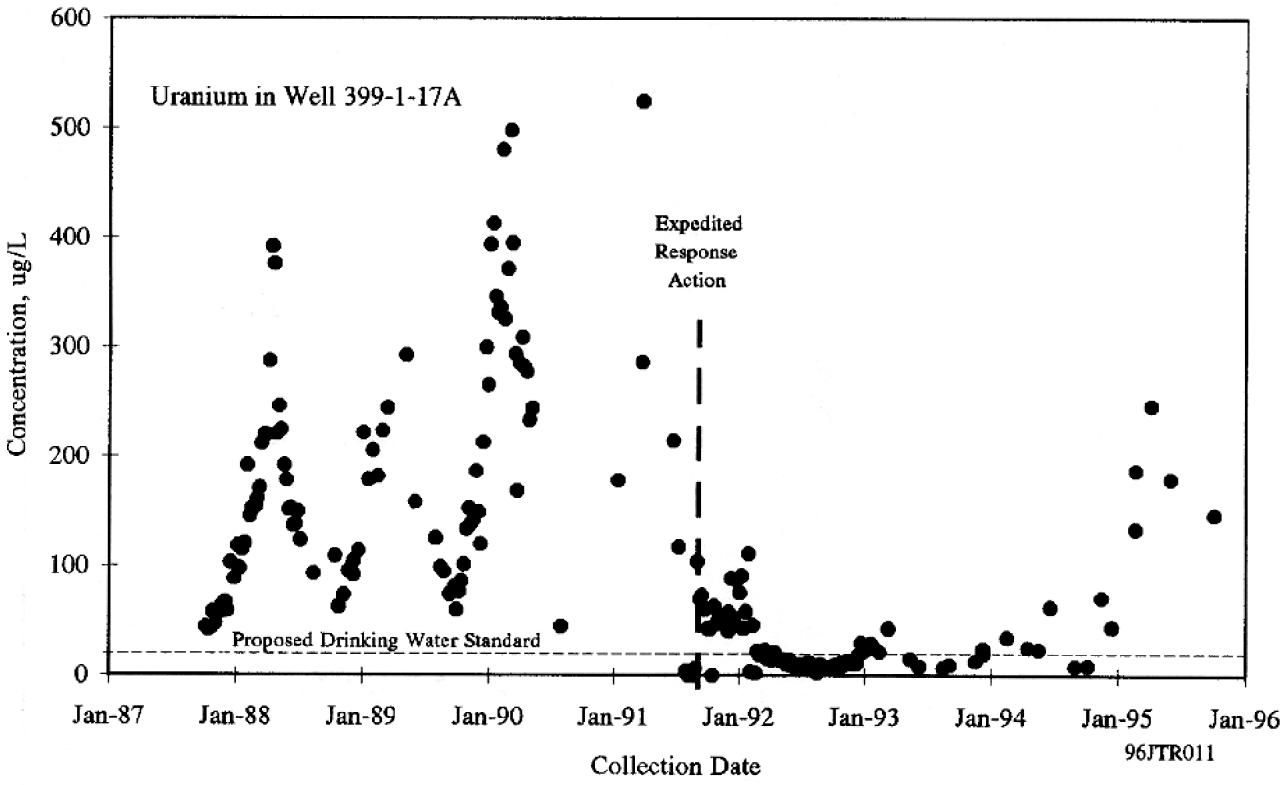

Figure 4.8.32. Uranium Concentrations in Well 399-1-17A, 1987 Through 1995

Cobalt-60 was detected near the Plutonium-Uranium Extraction Plant in a June 1994 sample from the 200-East Area well 299-E17-16 (40.1 pCi/L). This well consistently shows detectable but low levels of cobalt-60. However, samples from this well were not analyzed for cobalt-60 in 1995 due to changes in the Resource Conservation and Recovery Act monitoring and Operational Monitoring programs.

Cobalt-60 was occasionally detected at low levels in a few 200-West Area wells. Well 299-W14-12 continued to contain detectable cobalt-60 in 1995 samples. The highest value reported in this well was 17.2 pCi/L. This well is located to the east of the WMA-TY-TX single-shell tank farms. It is not known if the presence of cobalt-60 in the ground water results from tank leaks, other tank farm releases, or discharge to nearby cribs. The levels of cobalt-60 are well below regulatory standards and contribute little to the overall dose estimates for drinking water in this area. The concentrations and extent of the plume appear stable with time.

Cesium-137

Cesium-137 is produced as a high-yield fission product and is present in waste streams associated with fuel processing. Reactor operations may also result in the release of some cesium-137 associated with fuel element breaches. Cesium-137 is normally observed to be strongly sorbed on soil and thus is very immobile in Hanford ground water. The Drinking Water Standard for cesium-137 is 200 pCi/L, and the DOE Derived Concentration Guide is 3,000 pCi/L.

Cesium-137 is consistently detected in two wells, 299-E28-23 and 299-E28-25, located in the 200-East Area near the 216-B-5 Injection Well. The injection well received cesium-137-bearing wastes from 1945 to 1947. The maximum 1995 concentration of cesium-137 in well 299-E28-23 was 1,470 pCi/L, and the maximum concentration in well 299-E-28-25 was 90.1 pCi/L. Cesium-137 appears to be restricted to the immediate vicinity of the injection well by its extremely low mobility in ground water.

One cesium-137 sample from 200-West Area, well 299-W23-7, contained 21.8 pCi/L of cesium-137 in 1994. This well was not sampled in 1995. Well 299-W23-7 is located in the WMA-SX single-shell tank farm. This well was sampled in early 1996 in order to confirm the presence of cesium-137 in ground water at this location. In March 1996, 18 pCi/L of cesium-137 was detected in this well.

Plutonium

Plutonium has been released to the soil column in several locations in both the 200-West and 200-East Areas. Plutonium is generally considered to sorb strongly to sediments and thus has limited mobility in the aquifer. The DOE Derived Concentration Guide for either plutonium-239 or plutonium-240 is 30 pCi/L. There is no explicit Drinking Water Standard for plutonium-239; however, the total alpha Drinking Water Standard of 15 pCi/L would be applicable at a minimum. Alternately, if the DOE Derived Concentration Guide (which is based on a 100-mrem dose standard) is converted to the 4-mrem dose equivalent used for the Drinking Water Standard, 1.2 pCi/L would be the relevant guideline.

Ground water sampled at 200-East Area wells located near the 216-B-5 Injection Well ranged up to 53.3 pCi/L of plutonium-239,240 in well 299-E28-24 in 1995. This value is above the DOE Derived Concentration Guide, but is much lower than the 1994 maximum result of 2,670 pCi/L and generally agrees with results for 1994 and previous years. Plutonium-238 was also detected but at considerably lower levels, up to 0.228 pCi/L, in the same sample from well 299-E28-24. The presence of plutonium has been detected continuously in this area. Because plutonium is strongly adsorbed to sediments and may have been injected into the aquifer as suspended particles, it is likely that the values measured result in part from solid rather than dissolved material. However, plutonium-239,240 was also detected (0.178 pCi/L) in a sample from well 299-E28-2, which is approximately 150 m (490 ft) from the injection well. The 216-B-5 Injection Well received an estimated 244 Ci of plutonium-239, 240 during its operation from 1945 to 1947 (Stenner et al. 1988).

Antimony-125

Antimony-125 is produced as a fission product and is present in waste streams associated with fuel processing. Reactor operations may also result in the release of some antimony-125 associated with fuel element breaches. Antimony-125 tends to migrate in Hanford ground water with low retardation but generally has not been observed in recent years because of its relatively short half-life (2.7 years). The Drinking Water Standard for antimony-125 is 300 pCi/L.

Antimony-125 was detected at levels below the drinking water standard in 100-B Area well 199-B4-2 (27.1 pCi/L). It was also detected in several 100-K Area wells. The maximum concentration detected in the 100-K Area was 44.8 pCi/L in well 199-K-109A. Antimony-125 was also detected at a concentration of 21.1 pCi/L in well 699-35-70, which is located to the east of the 200-West Area Reduction-Oxidation Plant.

Chemical Monitoring Results for the Unconfined Aquifer

Chemical analyses performed in past years on ground-water samples by various monitoring programs at Hanford have identified eight hazardous chemicals that have been found in recent years at concentrations greater than existing or proposed federal Drinking Water Standards. These are nitrate, cyanide, fluoride, chromium, carbon tetrachloride, chloroform, trichloroethylene, and tetrachloroethylene.

A number of the parameters measured such as conductance, total carbon, total organic carbon, and total organic halogens are used as indicators of contamination. These will not be discussed in detail in this report. Other chemicals and parameters listed in Table 4.8.3 are indicators of the natural chemical composition of ground water and, in general, are not contaminants from operations at the Hanford Site. These include alkalinity, pH, sodium, magnesium, potassium, aluminum, silica, calcium, manganese, and iron. Chloride and sulfate are both naturally occurring and Site-related constituents. There is no primary Drinking Water Standard for chloride or sulfate (the secondary standard for each is 250 mg/L and is based on aesthetic rather than health considerations) so they will not be discussed in detail. The analytical technique used to determine the concentration of metals in ground water provides results for a number of constituents such as antimony, barium, beryllium, boron, cadmium, copper, nickel, silver, strontium, vanadium, and zinc that are rarely observed at greater than background concentrations.

The following subsections present additional information on the eight chemical constituents occurring in ground water at concentrations greater than existing or proposed Drinking Water Standards.

Nitrate

Most ground-water samples collected in 1995 were analyzed for nitrate. Nitrate was measured at concentrations greater than the Drinking Water Standard (45 mg/L as nitrate ion) in wells in all operational areas except the

100-B and 400 Areas. Nitrate is associated primarily with process condensate liquid wastes although other liquids discharged to the ground also contained nitrate. Nitrate contamination in the unconfined aquifer reflects the extensive use of nitric acid in decontamination and chemical reprocessing operations. However, additional sources of nitrate are located offsite to the south, west, and southwest. The distribution of nitrate on the Hanford Site is shown in Figure 4.8.33; this distribution is similar to previous evaluations. Although nitrate contamination can be detected over large areas of the Site, the areas impacted by levels greater than the Drinking Water Standard are smaller.

Most nitrate analyses performed onsite in recent years have been performed using an ion chromatography method. However, a colorometric method also has been used. The colorometric results appear prone to erratic errors. These results are currently being investigated. Several results for colorometric nitrate analyses have been excluded from the discussion below because they are off trend from other analyses and are considered suspect.

Nitrate in the 100 Areas. Nitrate is found at levels greater than the Drinking Water Standard in parts of the 100-D Area. The highest nitrate value found in the 100-D Area in 1995 was 184 mg/L in well 199-D8-3, located in the northern part of the Area near the Columbia River.

The 100-F Area also contains nitrate in ground water at levels greater than the Drinking Water Standard. This plume appears to extend to the south into the 600 Area but the extent of nitrate at low levels in the 600 Area west and south of the 100-F Area suggests there is also an unknown source upgradient. The maximum nitrate detected in the 100-F Area in 1995 was 117 mg/L in well 199-F7-3, located in the southwest part of the Area.

Nitrate in the 100-H Area is restricted to a small area downgradient of the 183-H Solar Evaporation Basins. The maximum concentration of nitrate detected in this area in 1995 was 1100 mg/L in well 199-H4-3.

Nitrate at levels greater than the Drinking Water Standard in the 100-K Area is found downgradient of both the K-East and K-West reactor buildings. The maximum concentration detected in 1995 was 131 mg/L in a sample from 199-K-30.

Minor nitrate contamination is found in parts of the 100-N Area. The maximum detected in a 1995 sample was 161 mg/L in well 199-N-67, located in the central part of the area.

Nitrate in the 200-East Area. The highest nitrate concentrations in the 200-East Area continued to be found near liquid waste disposal facilities that received effluent from Plutonium-Uranium Extraction Plant operations. Nitrate concentrations in wells near the 216-A-10 and 216-A-36B cribs generally have tended to decrease in the past few years but remained greater than the Drinking Water Standard even though these facilities were removed from service in 1987. The maximum nitrate concentration detected in this vicinity was 130 mg/L in well 299-E17-9 adjacent to the 216-A-10 Crib. The nitrate plume related to Plutonium-Uranium Extraction Plant operations is coincident with the tritium plume shown in Figure 4.8.12. However, as shown in Figure 4.8.33, nitrate is only found at levels above the Drinking Water Standard in a few restricted areas. High nitrate concentrations in the 600 Area north of the 200-East Area are apparently related to past disposal practices at the BY Cribs. Nitrate was detected in well 699-50-53A at 350 mg/L in 1995. Nitrate is also found in a few wells near the former Gable Mountain Pond, north of the 200-East Area.

Nitrate in the 200-West Area. Nitrate concentrations greater than the Drinking Water Standard were widespread in ground water beneath the 200-West Area and adjacent parts of the 600 Area. The major nitrate plumes were found in wells east of U Plant and wells in the north-central part of the 200-West Area. The highest nitrate concentrations across the Site continued to be found in wells east of U Plant near the 216-U-17 Crib, where the maximum concentration detected in 1995 was 1,400 mg/L in well 299-W19-30. The presence of nitrate in wells near this crib was observed before February 1988, when the crib went into operation. The source of nitrate is believed to be wastes disposed of in the 216-U-1 and 216-U-2 Cribs. These cribs received over 1,000,000 kg (2,200,000 lb) of nitrate during their operation from 1951 to 1967 (Stenner et al. 1988). Nitrate concentrations in wells located near the 216-U-1 and 216-U-2 Cribs west of U Plant continued to decrease, with concentrations in several of the wells dropping to less than the Drinking Water Standard.